Membrane Structure and Function

b) Cell membrane—transport

Whilst cell membranes are only about 7nm wide, they do represent a significant barrier to the movement of ions and molecules, particularly polar (water soluble) molecules such as glucose. This is because such molecules are repelled by the non-polar, hydrophobic lipids of the membranes. It is this lipid bilayer that prevents the aqueous contents of the cell from escaping.

However, transport across membranes has to occur for the following reasons:

- to obtain o_____ and n_____
- to excrete w_____ p_____
- to maintain a suitable _____ (or _____ concentration) within the cell for enzyme activity.
- to generate _i_____ gradients essential for nervous and muscular activity

Why do eukaryotic cells transport more across membranes than prokaryotic cells?

There are **four main mechanisms** by which molecules and ions can be transported across a membrane. They are:

1. **Diffusion** (simple and facilitated diffusion)
2. **Osmosis**
3. **Active transport**
4. **Bulk transport** (endocytosis and exocytosis)

Why are the first two processes classified as passive and the second two as active?

Membrane Structure and Function

1. Diffusion

This is the movement of molecules or ions in a **liquid or gas** from a region of their **high concentration** to a region of **lower concentration** down their **concentration gradient** until they are **equally distributed**.

Factors affecting diffusion

Rate of Diffusion depends on:

Diffusion is proportional to: $\frac{\text{Surface area x difference in concentration}}{\text{Length of the diffusion path}}$

Membrane Structure and Function

Fat soluble molecules can pass through the bi-layer. Charged particles or ions and large molecules such as Glucose cannot pass through the cell membrane because they are relatively insoluble in lipid.

Summarise the permeability to the cell membrane to the following groups of molecules.

Gases (**small non-polar/uncharged/soluble molecules**

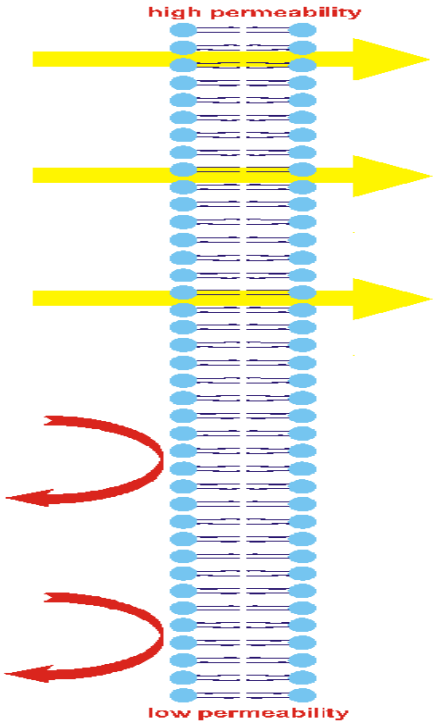
Very small polar molecules

(NB: water will diffuse slowly)

Larger, uncharged molecules

Charged Ions

Charged polar molecules



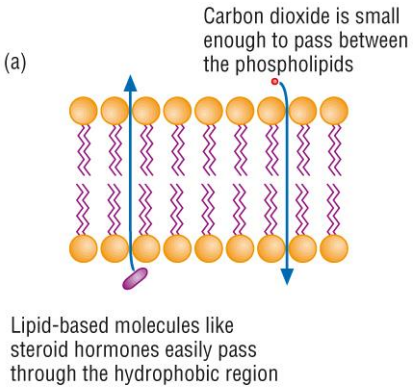
Types of diffusion

As the cell membrane is not equally permeable to all molecules, the cell has mechanisms to allow for the efficient diffusion of molecules to which it is normally impermeable. This type of diffusion is known as **facilitated diffusion**, whereas the movement of substances to which the membrane is readily permeable is known as **simple diffusion**.

Summarise the differences below.

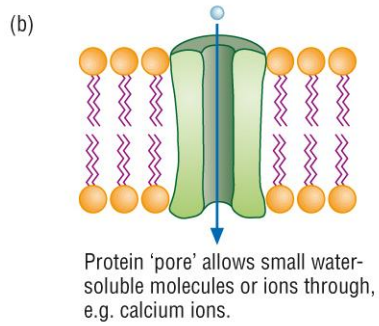
(a) Simple diffusion

Examples: Steroid hormones



Membrane Structure and Function

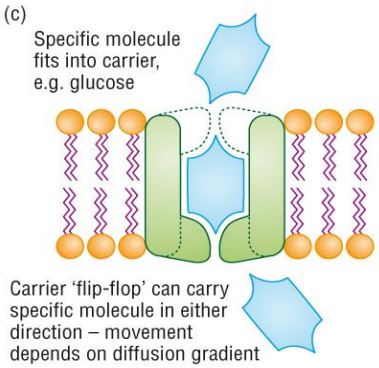
(b) Facilitated diffusion using a **ion channel protein**



Examples: Calcium ions, sodium ions

(c) Facilitated diffusion using a **carrier proteins**

Examples: glucose and amino acids



2. Osmosis

A special kind of diffusion

Although we use the term 'concentration' when we describe the relative amounts of solute in a solution, it is best to avoid using this term in reference to water. Instead, we use the term **water potential**. The process of water diffusion referred to as osmosis also always moves across a selectively permeable membrane.

Therefore, osmosis is the diffusion of water molecules from a region of **higher water potential** to a region of **lower water potential** (down a **water potential gradient**) across a **selectively permeable**

Membrane Structure and Function

membrane until the water is **equally distributed**.

The concept of water potential

Water molecules possess kinetic energy, which means that in liquid or gaseous form they move about rapidly and randomly from one location to another. The water potential of a given system such as the atmosphere, a solution, soil water or a cell is a **measure of the kinetic energy** of the water in the system.

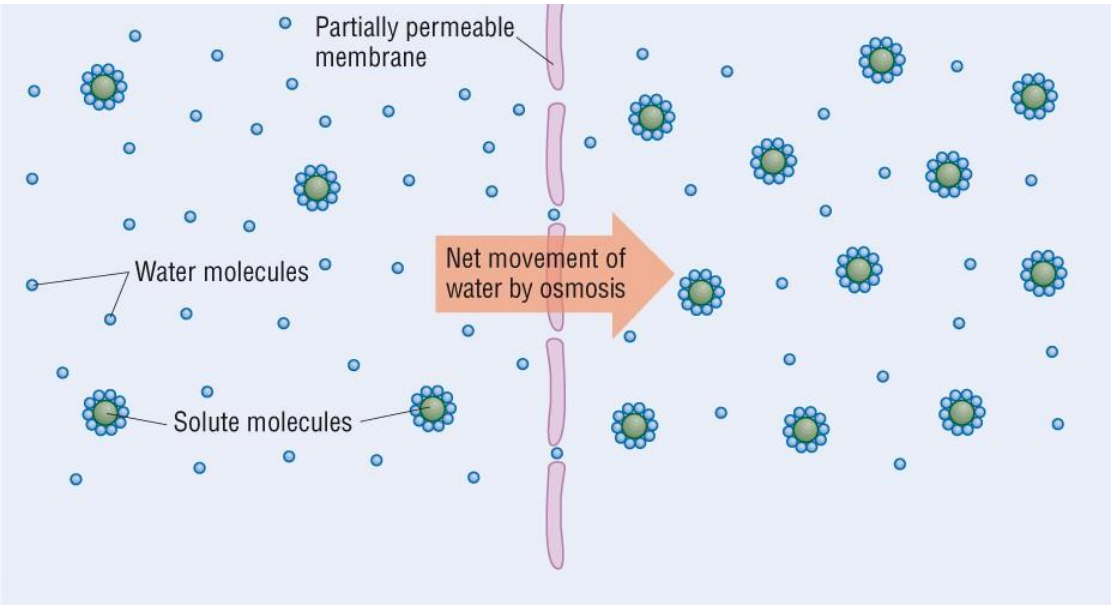
The **greater the concentration of water molecules** in a system, the **greater the total kinetic energy** of water molecules in that system and the **greater the water potential**. Pure water therefore has the highest water potential of any system. By convention, the water potential of pure water is zero and it is measured in **kilopascals (kPa)**.

When two systems containing water are in contact with each other (such as two cells next to each other or a cell next to a solution) the random movements of water molecules will result in the **net movement of water molecules from** the system with the **higher water potential** (higher kinetic energy) **to** the system with the **lower water potential** (lower energy) **until the concentration of water molecules** in both systems **is equal**.

So the water potential is the capacity of a system to lose water and is in effect the diffusion of water molecules.

When solute molecules or ions are dissolved in pure water they attract and hold water molecules to their surface. This reduces the number of water molecules that are free to diffuse out of the solution and therefore **lowers the water potential.**

All solutions therefore have lower water potentials than pure water. The more solute molecules present, the lower (more negative) the value. This means that when water flows down a water potential gradient, the net movement of water molecules is always from a less negative value e.g. -500 kPa to a more negative value e.g. – 800kPa.



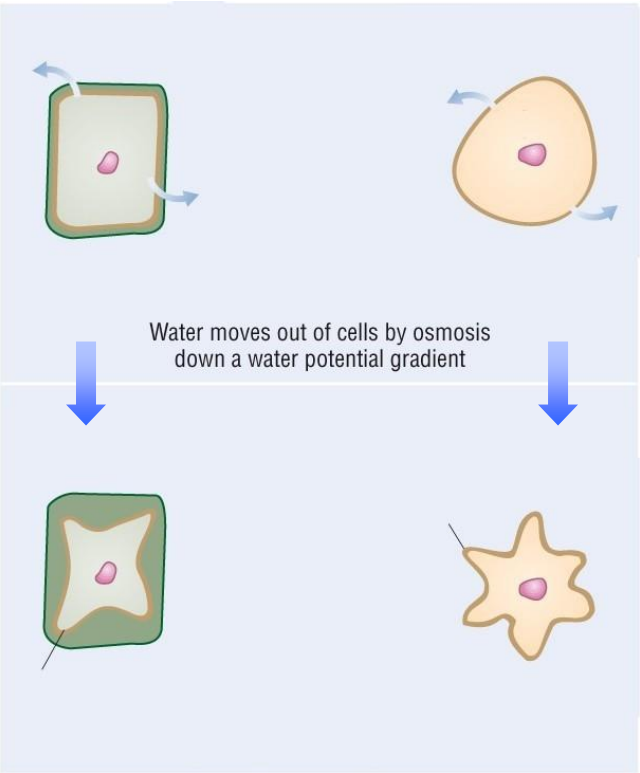
Membrane Structure and Function

Osmosis, water potential and cells

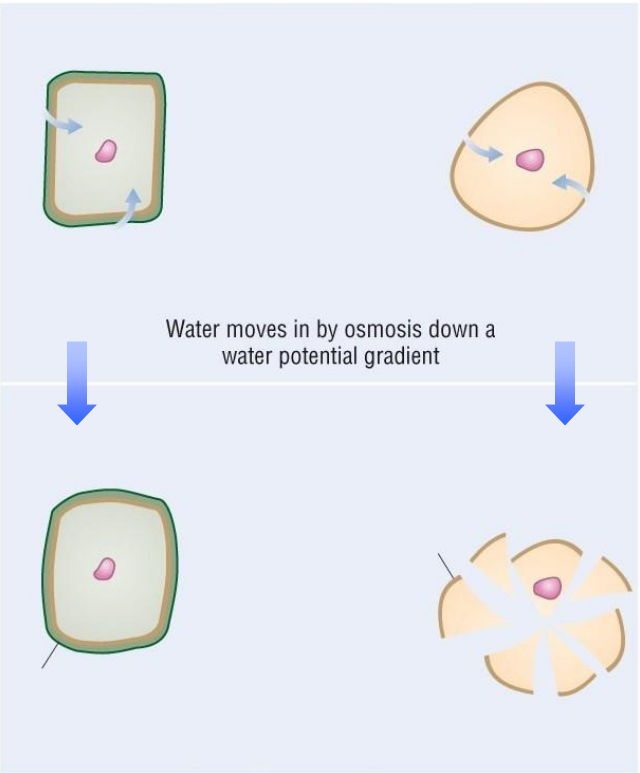
Why is the water potential of cells always lower than pure water?

Annotate the diagrams below to indicate whether the solution has a higher or lower water potential than the cells, what that means about the solute concentration and the effect on the cells (shown in the lower drawings).

SOLUTION _____ WATER POTENTIAL



SOLUTION _____ WATER POTENTIAL



What is the significance of the changes that occur to the plant cells shown above?

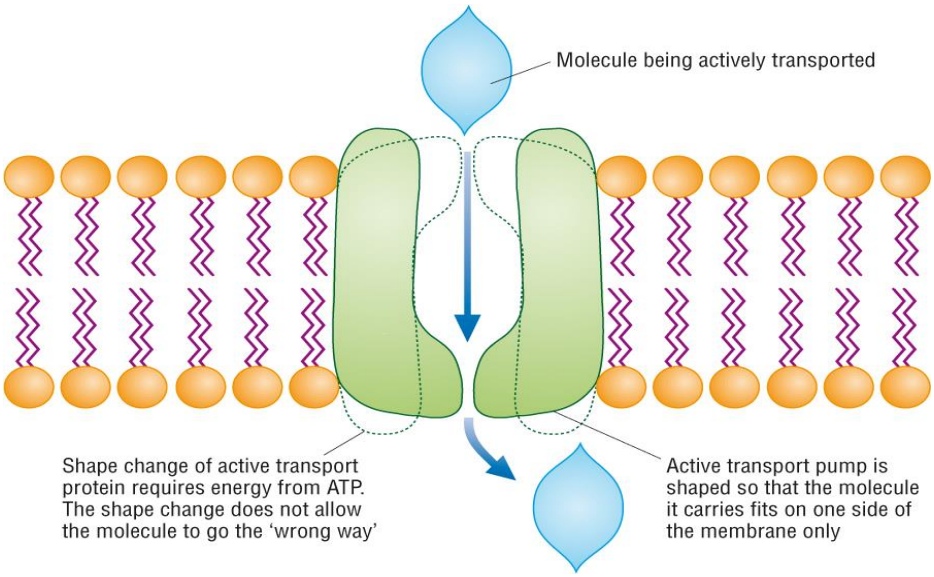
Describe an example of osmosis and animal cells

Membrane Structure and Function

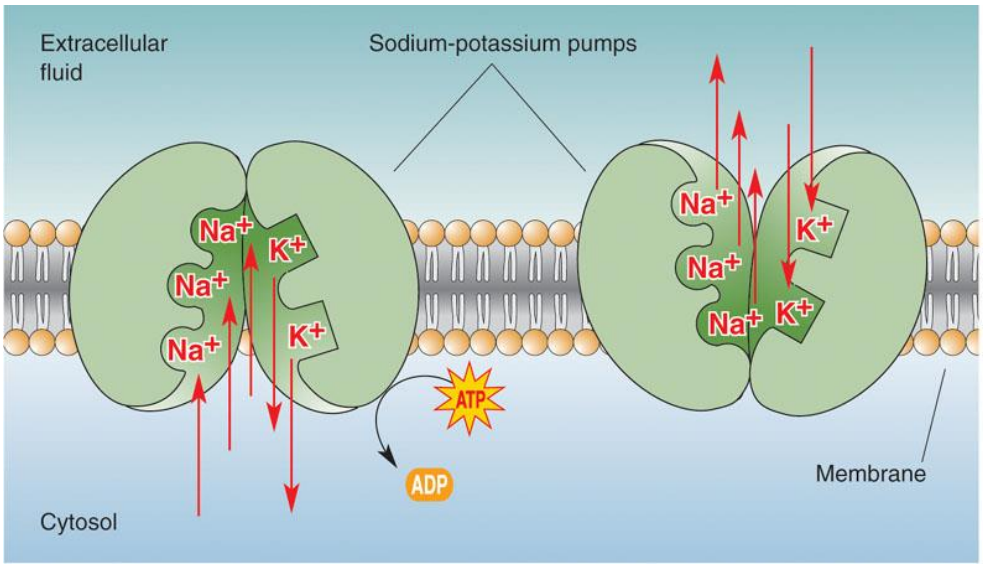
3. Active Transport

This process **uses energy** to move molecules and ions across the cell membranes **against a concentration gradient**. The molecules attach to **specific carrier proteins** (also called 'pumps') in the cell membrane, then molecules of **ATP** (adenosine triphosphate) are broken down to ADP (adenosine diphosphate) and an inorganic phosphate to **release energy**.

This energy changes the shape of the protein, as shown in the diagram below, and moves the molecule or ion across the membrane.



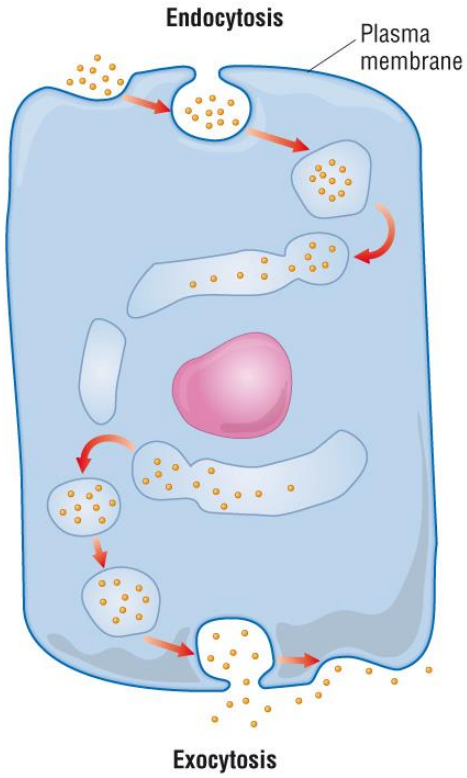
An example of active transport is the **sodium potassium pump** found in animal cell membranes. This pump is essential in controlling the osmotic balance in animal cells – it actively removes sodium ions from the cell. Too many sodium ions inside the cell would cause too much water to enter by osmosis leading to lysis. This pump is also important in many specialised cells such as those that absorb glucose in your small intestine.



Membrane Structure and Function

4. Bulk transport

This requires the use of energy which is supplied by the breakdown of ATP from respiration. Large quantities of material can be taken into the cell (**endocytosis)** as well as being moved out from a cell **(exocytosis)**.



Endocytosis:

Exocytosis:

Bulk transport can be divided into even more specific terms by the use of prefixes.

Write down the meaning of these prefixes and give examples.

* Endo-

* Exo-

* Phago-

* Pino-

Membrane Structure and Function

Annotate the diagram below to show the first three types of transport.